(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 039 124 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
04.12.2002 Bulletin 2002/49

(51) Int Cl.7: **F02N 11/08**

(21) Application number: **00100810.1**

(22) Date of filing: **17.01.2000**

(54) Automatic engine stop and restart system for vehicle

Automatische Stop-und Startanordnung fur Verbrennungsmotor eines Kraftfahrzeuges

Dispositif d'arrêt et de redémarrage automatique de moteur à combustion interne d'un véhicule

(84) Designated Contracting States:
DE FR GB

(30) Priority: **19.03.1999 JP 7622399**

(43) Date of publication of application:
27.09.2000 Bulletin 2000/39

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EP 1 039 124 B1

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present invention relates to an engine according to the preamble of independent claim 1, an automatic engine stop and restart control apparatus according to the preamble of independent claim 17 and an automatic engine stop and restart control process according to the preamble of independent claim 18.

[0002] JP-A-08 291725 shows a conventional automatic engine stop and restart system.

[0003] When a vehicle is stopped with an automatic transmission in the drive range, this conventional stop and restart system restarts the engine by forcibly holding the automatic transmission in the neutral range, and shifts the automatic transmission from the neutral range to the drive range when the engine speed reaches an idle speed. Therefore, this system tends to arouse unnatural feeling in the driver by a delay in producing the creep force of the automatic transmission, and produces a torque shock unexpectedly by allowing a torque converter to transmit, to a drive shaft, a torque proportional to the square of the engine speed when the transmission is shifted from the neutral range to the drive range. The torque shock is increased when the vehicle is restarted with the accelerator pedal being depressed.

[0004] It is, therefore, an object of the present invention to provide a vehicle, an automatic engine stop and restart apparatus and process as indicated above which can reduce an undesired torque shock in an automatic engine restart operation, and produce a driving force as demanded by a driver.

[0005] This objective is solved according to one aspect of the present invention by an vehicle according to the independent claim 1.

[0006] Further, this objective is solved according to another aspect of the present invention by an automatic engine stop and restart control apparatus according to the independent claim 17.

[0007] Furthermore, this objective is solved according to still another aspect of the present invention by an automatic engine stop and restart control process according to the independent claim 18.

[0008] According to a preferred embodiment, the controller sets the target engine speed for the automatic engine restart operation equal to an idle speed when the transmission is in a non-driving state (such as the N range and the P range) in which a driving torque is not transmitted through the transmission.

[0009] Further preferred embodiments of the present invention are laid down in the further subclaims.

[0010] In the following, the present invention is explained in greater detail by means of several embodiments thereof in conjunction with the accompanying drawings,
wherein:

Fig. 1 is a schematic view showing a vehicle equipped with an automatic engine stop and restart system according to one embodiment of the present invention.

Fig. 2 is a flowchart for showing a control process performed by the automatic engine stop and restart system of Fig. 1.

Fig. 3 is a graph showing a characteristic of a target engine speed used in the system of Figs. 1 and 2.

Fig. 4 is a time chart for illustrating operations of the automatic engine stop and restart system of Figs. 1 and 2.

Fig. 5 is a flowchart for showing a control process according to another embodiment of the present invention.

[0011] Fig. 1 shows a vehicle equipped with an automatic engine stop and restart system according to one embodiment of the present invention.

[0012] Between an engine 1 and an automatic transmission 3, there is provided a motor/generator (or motor) 2. The automatic transmission 3 of this example is a continuously variable transmission (CVT). Rotation of the engine 1 or the motor/generator 2 is transmitted through the automatic transmission 3 to a drive shaft 7 for driving drive wheels of the vehicle.

[0013] The engine 1 of this example may be a gasoline engine or a diesel engine. The automatic transmission 3 may be a multi-speed automatic transmission having a torque converter or a start clutch, instead of the CVT transmission.

[0014] The automatic transmission 3 of this example includes a torque converter 4, a forward-reverse changeover mechanism 5 and a belt type CVT unit 6 having variable pulleys 6a and 6b and a metal belt 6c connecting the pulleys 6a and 6b. The CVT unit 6 can vary the speed ratio between the input speed and the output speed continuously by varying the pulley ratio. The control system determines a target speed ratio in accordance with an operating condition, and controls primary and secondary oil pressures for driving the pulleys 6a and 6b so as to make the actual speed ratio equal to the target speed ratio. An external electric oil pump 14 supplies an oil pressure required for varying the speed ratio. The oil pump 14 can produce the oil pressure and supply the oil pressure to the automatic transmission 3 even when the engine 1 stops rotation. In this example, the oil pump 14 is a motor-driven pump external to the automatic transmission 3.

[0015] The forward and reverse changeover mechanism 5 is arranged to change the direction of the output rotation between the forward rotation and the reverse rotation to move the vehicle-forwards and backwards. The torque converter 4 transmits torque from the input member to the output member by dynamic fluid action. When the input speed is very low, the torque converter 4 allows the output member to stop rotation.

[0016] The motor/generator 2 of this example is directly connected with the crankshaft of the engine 1. Alternatively, it is optional to connect the motor/generator

2 with the engine 1 through a belt drive or a chain drive. The motor/generator 2 rotates in synchronism with the engine 1. The motor/generator 2 can function as an electric motor or a starter motor and as an electric generator. A power control unit 12 controls the operating mode, the speed (rpm) and the power generation quantity of the motor/generator 2.

[0017] When the motor/generator 2 serves as a motor to add assisting torque to the output of the engine 1, or to crank the engine 1, current is supplied from a battery 13 through the power control unit 12 to the motor/generator 2. When the motor/generator 2 serves as a generator to absorb running energy of the vehicle, generated current is supplied through the power control unit 12 to charge the battery 13.

[0018] An automatic stop and restart controller 10 is a main component of the automatic engine stop and restart system for automatically stopping the engine 1 when the vehicle is stopped temporarily and for automatically restarting the engine 1 to restart the vehicle. The stop and restart controller 10 stops the engine 1 when the vehicle comes to a halt, and restarts the engine 1 with the motor/generator 2 to restart the vehicle.

[0019] The stop and restart controller 10 receives input information on vehicle operating conditions from an engine speed sensor 9, a brake sensor 11, an accelerator sensor 15, a select position sensor 17 for sensing a select position of the automatic transmission 3, and a vehicle speed sensor 18. In accordance with signals from these sensors, the stop and restart controller 10 performs the automatic engine stop and restart control. Specifically, the stop and restart controller 10 according to this embodiment of the invention performs an automatic engine restart operation with the motor/generator 2 while the automatic transmission 3 is in the state capable of transmitting engine rotation therethrough. By so doing, this restart system produces the driving force and the creep force as expected by the driver in restarting so as to avoid unnatural feeling, and reduces a shock in restarting.

[0020] Fig.2 shows an automatic stop and restart control process performed by the stop and restart controller 10. This process is performed after the warm-up operation of the engine. When, for example, the vehicle is stopped at a crossing, this system automatically stops the engine 1 and restarts the engine 1.

[0021] At a step S1, the controller 10 checks if the engine warm-up operation is completed and the engine 1 is in a warmed-up state. Then, at steps S2 ~ S5, the controller 10 further checks the conditions of the brake pedal, the vehicle speed, the accelerator pedal and the engine speed. The controller 10 proceeds to a step S6 if the engine 1 is in the warmed-up state, the brake pedal is depressed, the vehicle speed is zero, the accelerator pedal is released, and the engine speed is in an idling range (for example, equal to or lower than 800 rpm). At the step S6, the controller 10 checks if these conditions are satisfied for the first time, by checking if FCOND = 0.

[0022] When FCOND = 0, the controller 10 sets a stop delay time for delaying a stoppage of the engine 1, and sets FCOND to one (FCOND=1) at a step S7. After the step S7, the controller 10 proceeds to a step S8. For example, the stop delay time is equal to 2 seconds. This system stops the engine 1 at the end of the delay time starting from the time point at which all the conditions are first satisfied. When FCOND = 1, the controller 10 proceeds from the step S6 directly to the step S8.

[0023] At the step S8, the controller 10 examines the shift position of the automatic transmission 3. When the shift position is not the R range, then the controller 10 resets a flag FRFST to zero (FRFST =0) at a step S9 to initiate an automatic stop operation. Then, the controller 10 checks, at a step S10, whether the engine 1 is in a stop state, or not. In this example, the automatic stop and restart operation is performed not only in the D range, but in the L range, S range, N (neutral) range and P (parking) range as well.

[0024] If the engine 1 is not stopped, the controller 10 proceeds from the step S10 to a step S11, and checks, at the step S11, if the delay time has elapsed. When the delay time has elapsed from the time point at which all the conditions of the steps S1 ~ S5 become satisfied, the controller 10 enters the program section S12 ~ S17 for the automatic engine stop operation.

[0025] In the engine stop mode for automatically stopping the engine 1, the controller 10 reduces the torque of the motor/generator 2 to zero at the step S13, and stops the fuel injection for the engine 1 at the step S14. Then, at the step S15, the controller 10 checks if FISTPFST = 0, to examine whether this is the first operation in the automatic engine stop mode. When the current execution is the first execution of the engine stop mode, the controller 10 proceeds from the step S15 to the step S16, at which the controller 10 sets an idling stop permission time, and sets the flag FISTPFST to one (FISTPFST=1) to indicate the setting of the idling stop permission time. At the step S17, the controller 10 resets a flag FENGSTRT to zero (FENGSTRT=0) to indicate that the engine 1 is in the automatic stop state. Thus, the engine 1 is put in the stop state.

[0026] When any one or more of the conditions of the steps S1 ~ S4 become unsatisfied, the controller proceeds to a step S18. That is, the controller proceeds to the step S18 if the engine 1 is not in the warmed-up state, or if the brake pedal is released, or if the accelerator pedal is depressed, or if the vehicle speed becomes greater than zero. The controller 10 resets the flag FCOND to zero (FCOND =0) to indicate that the engine stop condition becomes unsatisfied at the step S18, and checks, at a step S19, whether the engine 1 is in the stop state. When the engine 1 is in the stop state, the controller 10 proceeds from the step S19 to a step S22 to restart the engine 1.

[0027] When the engine 1 is not in the stop state, the controller 10 proceeds from the step S19 to a step S20, and resets the idling stop permission flag FISTPFST to

zero (FISTPFST=0) at the step S20.

[0028] When the engine stop condition is satisfied, and the engine 1 is already in the stop state, the controller 10 proceeds from the step S10 to a step S21, and examines if the idling stop permission time (set at the step S16) has elapsed. When the idling stop permission time has elapsed, the controller 10 initiates the automatic engine restart operation of steps S22 ~ S28 and S33 ~ S36.

[0029] The controller 10 initiates the automatic engine restart operation at the step S22, and checks whether this is the first operation in the automatic engine restart mode, by checking whether FENGSTRT = 0 at the step S23. In the case of the first operation (FENGSTRT=0), the controller 10 sets a restart delay time and sets FENGSTRT to one (FENGSTRT=1) at the step S24. The restart delay time is set equal to a time (1.5 second, for example) required to develop an intake boost to a level of about -400 mmHg (≅48 kPa) in restarting. During this restart delay time, the system cranks the engine 1 without injecting fuel, and thereby obtains a smooth engine starting operation.

[0030] At the step S25, the controller 10 checks if the accelerator pedal is in the off (non-depressed) state. In the case of a restart with the accelerator pedal being in the non-depressed state, the controller 10 sets a target engine speed at an idle speed (the target speed = the idle speed) at the step S26, and waits for the elapse of the restart delay time at the step S27. Then, the control system starts the fuel injection at the step S28.

[0031] When the accelerator pedal is depressed, the controller 10 proceeds from the step S25 to the step S33 and checks if the engine 1 is in a complete explosion state. When the engine 1 is in the complete explosion state, the controller 10 proceeds to the step S35, and performs the torque control of the motor/generator 2 to reduce the motor torque to zero. It is possible to detect the complete explosion state of the engine, for example, by examining if the engine speed reaches a predetermined level.

[0032] When the engine 1 is not in the complete explosion state, the controller 10 proceeds to the step S34, sets the target engine speed, and cranks the engine 1 with the motor/generator 2. In this case, the control system determines the target engine speed from a target driving force, or from the accelerator opening (degree) and the time from a start of an engine starting operation, as a function of the accelerator opening and the time from the start of the engine starting operation, and controls the revolution speed of the motor/generator 2.

[0033] Then, the control system starts the fuel injection at the step S36.

[0034] The target driving force produced by the motor/generator 2 in place of the engine 1 is a driving force corresponding to the force of creep when the automatic transmission 3 is driven by the engine 1 through the torque converter 4.

[0035] The output of the torque converter 4 is calculated from a torque ratio t determined in accordance with a speed ratio between input and output speed, a torque capacity τ, and an engine speed Ne, as $t \times \tau \times Ne^2$. The required driving force is a driving force at a drive wheel, so that it is converted to an output torque of the torque converter by using the wheel radius, the final gear ratio, and the speed ratio of the transmission.

[0036] Accordingly, the target input speed (the engine speed) N of the torque converter 4 is given by; $N = (TED0/GRBYRT/RATIO/TRQRTO/TAU)^{1/2}$. In this equation, TED0 is the driving force, GRBYRT is the final gear ratio/the wheel radius, RATIO is the actual speed ratio, TRQRTO is the torque ratio of the torque converter 4, and TAU is the capacity of the torque converter 4.

[0037] Alternatively, it is possible to determine the target speed by lookup from a map as shown in Fig. 3, as a function of the depression degree (accelerator opening) of the accelerator pedal and the time from a start of the restarting operation (or the vehicle speed after the start of the restarting operation). As shown in Fig. 3, the target speed increases as the time from a start of the starting operation increases, and the rate of increase of the target speed increases as the accelerator opening increases.

[0038] After the start of the fuel supply, the engine 1 produces a torque. Therefore, the target speed used in this control is based on a sum of the torque of the engine 1 and the torque of the motor/generator 2. If the engine speed increases excessively by the torque of the engine 1, the motor/generator 2 serves as a load by functioning as an electric generator and thereby prevents the engine speed from increasing beyond the target speed.

[0039] This control system restarts the engine 1 without changing the shift position of the automatic transmission 3. When the automatic transmission 3 is in the D range, this control system holds the automatic transmission 3 invariably in the D range during the restart operation, and produces the force of creep corresponding to the idle speed, from the beginning if the accelerator pedal is not depressed. If the automatic transmission 3 is in the N range, the control system controls the input speed of the automatic transmission 3 equal to the idle speed without providing the creep. In any case, this control system does not produce a shock due to a return to the D range from the N range as in a conventional system.

[0040] When the select position of the automatic transmission 3 is in the R range, the controller 10 proceeds from the step S8 to a step S29 and examines, at the step S29, whether the engine 1 is in the stop state. When the engine 1 is in the stop state, the controller 10 proceeds to a step S30, and checks the flag FRFST reset at the step S9 to determine whether this is the first operation in the R range mode. In the case of the first operation in the R range mode, FRFST = 0, and hence the controller 10 proceeds to a step S31. At the step S31, the controller 10 sets a delay time (2 seconds, for example) for engine stoppage, and sets the flag FRFST

to one (FRFST=1).

[0041] At the end of the delay time set at the step S31, the controller 10 proceeds from the step S32 to the step S22 and starts the engine restart operation of the steps S22 ~ S28 and S33 ~ S36.

[0042] Fig. 4 illustrates operations of the control system according to this embodiment. The feature of this automatic engine stop and restart system according to this embodiment resides in the engine restart control.

[0043] In the example of Fig. 4, the stop and restart system restarts the engine 1 in the D range. When the driver releases the brake pedal in the automatic stop state in which the engine is automatically stopped, the system terminates the idling stop operation, and starts the cranking operation of the engine 1 with the motor/generator 2.

[0044] The motor/generator 2 forcibly turns the engine 1, and accordingly the torque converter 4 produce the creep force. Even when the engine 1 is in the stop state in which the engine is stationary, the external oil pump 14 supplies the oil pressure, so that the line pressure in the automatic transmission 3 is held at the normal level. Therefore, in the D range, the CVT unit 6 is in the drive state with the variable pulley pressure held at a level maintaining the driving connection without slippage of the metal belt 6, and the forward clutch of the forward reverse mechanism 5 is held in the engaged state. This system prevents the oil pressure from becoming excessive and thereby minimizes the loss of driving the pump to protect the fuel economy.

[0045] At the end of a predetermined short time (1.5 second, for example) after the start of the engine cranking operation, the system starts the fuel injection, so that the engine torque increases. The predetermined short time is a time required to develop an engine boost to a level of about -400 mmHg (≅48 kPa). In this way, this system waits for a build up of engine boost, and then starts the fuel injection, so that the combustion torque is relatively small, and the torque is varied smoothly from the torque of the motor/generator 2 to the torque of the engine 1. This system controls the sum of the engine torque and the motor/generator torque so as to make the sum equal to the target driving torque.

[0046] In the state in which the engine torque increases sharply, the input speed of the automatic transmission 3 tends to increase beyond the target speed in the manner of overshoot. In this case, the motor/generator 2 is operated as a generator, and absorbs an excess of the engine output so that the produced torque becomes equal to the target torque and the creep force is held at a desired value.

[0047] After the engine 1 has reached the state of self-supporting revolution, the system returns the engine to the normal operating state when the actual engine speed increases to the target engine speed and the required motor torque becomes zero.

[0048] During this engine restarting operation, the select position of the automatic transmission 3 is held unchanged. When, for example, the select position is in the D range, the engine 1 is restarted in the D range, and the creep force is produced from the start of the engine starting operation, first by the motor/generator 2 and then by the engine 1. Therefore, this system can prevent unnatural feeling, and a shock which would be caused if the transmission is held in the neutral state and returned to the drive range.

[0049] When the engine 1 is restarted in the N range, this system produces no creep force. In this case, however, the driver is aware that the select position is in the N range, and anticipates a shock due to a shift from the N range to the D range as usual.

[0050] When the engine 1 is restarted in the state in which the accelerator pedal is depressed by the driver, this system can increase the driving force rapidly as demanded by the driver. In this case, the control system sets the target speed in the restarting operation so that the target speed increases as the accelerator opening increases, and the target speed increases as the time from the start of the engine starting operation or the vehicle speed increases. Since the engine speed cannot increase immediately, the control system increases the torque of the motor/generator 2. Therefore, the motor/generator 2 increases its speed sharply while rotating the engine 1, and thereby produces the driving torque as requested by the driver. The control system reduces the output of the motor/generator 2 to zero when the engine speed reaches the target speed. The motor/generator 2 produces electric energy by consuming the engine torque when the battery 13 is to be charged, or when a regenerative operation is required during deceleration.

[0051] Fig. 5 shows a control process according to a second embodiment of the present invention. The control process of Fig. 5 is different from Fig. 2 only in the addition of a step S50 between the step S24 and the step S25. At the step S50, the controller 10 checks the driving condition of the automatic transmission 3. In this example, the controller 10 proceeds from the step S50 directly to the step S26 if the automatic transmission 3 is in the N or P range. Otherwise, the controller 10 proceeds from the step S50 to the next step S25. Therefore, in the example of Fig. 5, the target engine speed is set at the idle speed in the case of the N or P range, without regard to the accelerator opening degree.

[0052] The system according to the second embodiment can prevent the engine speed from being increased even if the driver races the engine in the N or P range. This adds a contribution to the improvement of fuel economy and reduction of noises. On the other hand, the control system according to the first embodiment can provide a natural feeling as in an ordinary vehicle, by allowing the engine speed to increase in response to depression of the accelerator pedal in the N or P range.

[0053] The present invention is not limited to the embodiments described above. Modifications and varia-

tions of the embodiments described above will occur to those skilled in the art in light of the above teachings.

Claims

1. A vehicle comprising:

   an engine (1);
   a motor (2) for starting the engine (1);
   an automatic transmission (3) connected with the engine (1) and the motor (2), for receiving input rotation from the engine (1) and the motor (2) and providing output rotation to drive the vehicle;
   a sensing device (9,11,15,18) for sensing a vehicle operating condition; and
   a controller (10,12) for performing an automatic engine stop operation for automatically stopping the engine (1) and an automatic engine restart operation for automatically restarting the engine (1) in accordance with the vehicle operating condition, for producing an engine restart request signal to request a restart of the engine (1) during the automatic engine stop operation, **characterized in that** said controller (10) is adapted for determining a target engine speed for the automatic engine restart operation, and for performing the automatic engine restart operation, in response to the engine restart request signal, by driving the motor in accordance with the target speed while holding a transmission state of the automatic transmission (3) unchanged.

2. A vehicle according to claim 1, **characterized in that** the controller (10) is configured to perform the automatic engine restart operation in response to the engine restart request signal, and to hold the automatic transmission (3) in a drive range during the automatic engine restart operation if the automatic transmission is in the drive range at the start of the engine restart operation.

3. A vehicle according to claim 1 or 2, **characterized in that** the controller (10) produces a first condition signal when an accelerator pedal of the vehicle is depressed, a second condition signal when a brake pedal of the vehicle is released, a third condition signal when a vehicle speed of the vehicle is increased from zero, and a fourth condition signal when a time duration of the automatic engine stop operation becomes equal to or greater than a predetermined time length, and the controller (10) produces the restart request signal when at least one of the first, second, third and fourth condition signals is produced.

4. A vehicle according to at least one of the preceding claims 1 to 3, **characterized in that** the sensing device comprises an accelerator sensor (15) for sensing a condition of the accelerator pedal of the vehicle, a brake sensor (11) for sensing a condition of the brake pedal of the vehicle, and a vehicle speed sensor (18) for sensing the vehicle speed of the vehicle, and the controller (10) produces the first, second and third condition signals, respectively, in accordance with signals from the accelerator sensor (15), the brake sensor (11) and the vehicle speed sensor (18).

5. A vehicle according to at least one of the preceding claims 1 to 4, **characterized in that** the controller (10) determines the target engine speed for the automatic engine restart operation in accordance with an accelerator opening degree.

6. A vehicle according to claim 5, **characterized in that** the controller (10) sets the target engine speed equal to an idle speed when the accelerator opening degree is equal to a minimum setting.

7. A vehicle according to claim 5 or 6, **characterized in that** the controller (10) increases the target engine speed for the automatic engine restart operation in accordance with the accelerator opening degree.

8. A vehicle according to at least one of the preceding claims 1 to 4, **characterized in that** the controller (10) increases the target engine speed for the automatic engine restart operation in accordance with an operating parameter which is one of a time elapsed from a start of the automatic engine restart operation and a vehicle speed of the vehicle.

9. A vehicle according to claim 8, **characterized in that** the controller (10) increases a rate of increase of the target engine speed with respect to the parameter as the accelerator opening degree increases.

10. A vehicle according to claim 1, **characterized in that** the controller (10) sets the target engine speed for the automatic engine restart operation equal to an idle speed when the automatic transmission (3) is in a non-driving state in which a driving torque is not transmitted through the automatic transmission (3).

11. A vehicle according to at least one of the preceding claims 1 to 10, **characterized in that** the sensing device further comprises a transmission condition sensor for sensing a condition of the automatic transmission (3), and the controller (10) checks the condition of the automatic transmission (3) in re-

sponse to the restart request signal and determines the target engine speed for the automatic engine restart operation in accordance with the condition of the automatic transmission (3).

12. A vehicle according to at least one of the preceding claims 1 to 11, **characterized in that** the controller (10) controls a torque of the engine (1) and a torque of the motor (2) in the automatic engine restart operation so as to make an actual engine speed equal to the target speed.

13. A vehicle according to claim 12, **characterized in that** the sensing device comprises an engine speed sensor (9) for sensing an actual engine speed of the engine (1), and the controller (10) controls the motor (2) in the automatic engine restart operation so as to reduce a deviation of the actual engine speed from the target engine speed.

14. A vehicle according to at least one of the preceding claims 1 to 13, **characterized in that** the controller (10) operates the motor (2) in a power generating mode for generating electric power by absorbing energy of the engine (1) when the actual engine speed is higher than the target speed.

15. A vehicle according to at least one of the preceding claims 1 to 14, **characterized in that** in the automatic engine restart operation, the controller (10) first cranks the engine (1) with the motor (2) without fuel injection for a predetermined time duration to increase an engine boost to a predetermined level, and starts fuel supply to the engine (1) at the end of the predetermined time duration.

16. A vehicle according to at least one of the preceding claims 1 to 15, **characterized in that** the vehicle further comprises an oil pump (14) for supplying oil pressure to the automatic transmission (3) even when the engine (1) is at rest.

17. An automatic engine stop and restart control apparatus for automatically stopping an engine (1) for a vehicle and automatically restarting the engine (1) with a starting motor (2), the automatic engine stop and restart control apparatus comprising:

means for automatically stopping the engine (1) in a predetermined vehicle situation;
means for monitoring a driving condition of an automatic transmission (3) connected with the engine (1), **characterized by**
means for producing an automatic restart request signal in accordance with a vehicle operating condition in the predetermined vehicle situation;
means for determining a target engine speed for an automatic engine restart operation in accordance with the driving condition of the automatic transmission (3); and
means for restarting the engine (1) in response to the automatic engine restart request signal, by controlling the starting motor (2) in accordance with the target engine speed.

18. An automatic engine stop and restart control process for automatically stopping an engine (1) for a vehicle and automatically restarting the engine (1) with a starting motor (2), the automatic engine stop and restart control process comprising:

putting the engine (1) in an automatic stop state in a predetermined vehicle situation;
detecting a driving condition of an automatic transmission (3) connected with the engine (1), **characterized by**
producing an automatic restart request signal in accordance with a vehicle operating condition in the predetermined vehicle situation; determining a target engine speed for an automatic engine restart operation in accordance with the driving condition of the automatic transmission (3); and
initiating the automatic engine restart operation for restarting the engine (1) in response to the automatic engine restart request signal, by controlling the starting motor (2) in accordance with the target engine speed.

Patentansprüche

1. Ein Fahrzeug mit:

einem Verbrennungsmotor (1);
einem Motor (2) zum Starten des Verbrennungsmotors (1);
einem automatischen Getriebe (3), verbunden mit dem Verbrennungsmotor (1) und
dem Motor (2) zum Aufnehmen der Eingangsdrehung von dem Verbrennungsmotor (1) und dem Motor (2) und zum Schaffen einer Ausgangsdrehung, um das Fahrzeug anzutreiben;
einer Erfassungvorrichtung (9, 11, 15, 18) zum Erfassen eines Fahrzeugbetriebszustandes; und
einer Steuerung (10, 12) zum Ausführen eines automatischen Motorstoppbetriebes zum automatischen Anhalten des Verbrennungsmotors (1) und eines automatischen Neustarts des Verbrennungsmotors (1) in Übereinstimmung mit dem Fahrzeugbetriebszustand, zum Erzeugen eines Verbrennungsmotor- Neustartanforderungssignales, um einen Neustart des Verbrennungsmotors (1) während des automati-

schen Motorstoppbetriebes anzufordern, **dadurch gekennzeichnet, daß** die Steuerung (10) angepaßt ist, um eins Zielmotordrehzahl für den automatischen Motomeustartbetrieb zu bestimmen und um den automatischen Verbrennungsmotor- Neustartbetrieb in Abhängigkeit von dem Motor- Neustartanforderungssignal durch Antreiben des Motors in Übereinstimmung mit der Zieldrehzahl auszuführen, während des unveränderten Beibehaltens eines Übertragungszustandes des automatischen Getriebes (3).

2. Fahrzeug nach Anspruch 1, **dadurch gekennzeichnet, daß** die Steuerung (10) ausgelegt ist, einen automatischen Verbrennungsmotor- Neustartbetrieb in Abhängigkeit von dem Verbrennungsmotor- Neustartanforderungssignal auszuführen und um das automatischen Getriebe (3) während des automatischen Verbrennungsmotor- Neustartbetriebes in einem Antriebsbereich zu halten, wenn das automatische Getriebe in dem Antriebsbereich bei dem Start des Verbrennungsmotor- Neustartbetriebes ist.

3. Fahrzeug nach Anspruch 1 oder 2, **dadurch gekennzeichnet, daß** die Steuerung (10) ein erstes Zustandssignal erzeugt, wenn ein Beschleunigerpedal des Fahrzeuges niedergedrückt wird, ein zweites Zustandssignal, wenn ein Bremspedal des Fahrzeuges freigegeben wird, ein drittes Zustandssignal, wenn eine Fahrzeuggeschwindigkeit des Fahrzeuges von Null erhöht wird, und ein viertes Zustandssignal, wenn eine Zeitdauer des automatischen Motorstoppbetriebes gleich wird zu oder größer als eine vorbestimmte Zeitdauer, und die Steuerung (10) das Neustartanforderungssignal erzeugt, wenn zumindest eines der ersten, zweiten, dritten oder vierten Zustandssignale erzeugt wird.

4. Fahrzeug nach zumindest einem der vorhergehenden Ansprüche 1 bis 3, **dadurch gekennzeichnet, daß** die Erfassungsvorrichtung einen Beschleunigersensor (15) aufweist, zum Erfassen eines Zustandes des Beschleunigerpedales des Fahrzeuges, einen Bremssensor (11) zum Erfassen eines Zustandes des Bremspedals des Fahrzeuges und einen Fahrzeuggeschwindigkeitssensor (18) zum Erfassen der Fahrzeuggeschwindigkeit, und die Steuerung (10) jeweils das erste, zweite und dritte Zustandssignal in Übereinstimmung mit den Signalen von dem Beschleunigersensor (15), dem Bremssensor (11) und dem Fahrzeuggeschwindigkeitssensor (18) erzeugt.

5. Fahrzeug nach zumindest einem der vorhergehenden Ansprüche 1 bis 4, **dadurch gekennzeichnet, daß** die Steuerung (10) die Zielmotordrehzahl für den automatischen Motomeustartbetrieb in Übereinstimmen mit einem Beschleunigeröffnungsgrad bestimmt.

6. Fahrzeug nach Anspruch 5, **dadurch gekennzeichnet, daß** die Steuerung (10) die Zielmotordrehzahl gleich zu einer Leerlaufdrehzahl festlegt, wenn der Beschleunigeröffnungsgrad gleich zu einer minimalen Einstellung ist.

7. Fahrzeug nach Anspruch 5 oder 6, **dadurch gekennzeichnet, daß** die Steuerung (10) die Zielmotordrehzahl für einen automatischen Motomeustartbetrieb in Übereinstimmen mit dem Beschleunigeröffnungsgrad erhöht.

8. Fahrzeug nach zumindest einem der vorhergehenden Ansprüche 1 bis 4, **dadurch gekennzeichnet, daß** die Steuerung (10) die Zielmotordrehzahl für einen automatischen Motomeustartbetrieb in Übereinstimmung mit einem Betriebsparameter erhöht, der einer von einer Zeit, verstrichen von einem Start des automatischen Motomeustartbetriebes, oder eine Fahrzeuggeschwindigkeit des Fahrzeuges ist.

9. Fahrzeug nach Anspruch 8, **dadurch gekennzeichnet, daß** die Steuerung (10) eine Rate der Erhöhung der Zielmotordrehzahl in Bezug auf den Parameter erhöht, wenn der Beschleunigeröffnungsgrad zunimmt.

10. Fahrzeug nach Anspruch 1, **dadurch gekennzeichnet, daß** die Steuerung (10) die Zielmotordrehzahl für den automatischen Motomeustartbetrieb gleich zu einer Leerlaufdrehzahl festlegt, wenn das automatische Getriebe (3) in einem Nicht- Antriebszustand ist, in dem kein Antriebsdrehmoment durch das automatische Getriebe (3) übertragen wird.

11. Fahrzeug nach zumindest einem der vorhergehenden Ansprüche 1 bis 10, **dadurch gekennzeichnet, daß** die Erfassungsvorrichtung weiter einen Getriebezustandssensor zum Erfassen eines Zustandes des automatische Getriebes (3) aufweist, und die Steuerung (10) den Zustand des automatischen Getriebes (3) in Abhängigkeit von dem Neustartanforderungssignal prüft und die Zielmotordrehzahl für den automatischen Motomeustartbetrieb in Übereinstimmung mit dem Zustand des automatischen Getriebes (3), festlegt.

12. Fahrzeug nach zumindest einem der vorhergehenden Ansprüche 1 bis 11, **dadurch gekennzeichnet, daß** die Steuerung (10) ein Drehmoment des Verbrennungsmotors (1) und ein Drehmoment des Motors (2) in dem automatischen Motomeustartbetrieb steuert, um so eine tatsächliche Motordreh-

zahl gleich der Ziehldrehzahl zu machen.

13. Fahrzeug nach Anspruch 12, **dadurch gekennzeichnet, daß** die Erfassungsvorrichtung einen Motordrehzahlsensor (9) zum Erfassen einer tatsächlichen Motordrehzahl des Verbrennungsmotors (1) aufweist, und die Steuerung (10) den Motor (2) in dem automatischen Motomeustartbetrieb steuert, um so eine Abweichung der tatsächlichen Motordrehzahl von der Ziehldrehzahl zu vermindern.

14. Fahrzeug nach zumindest einem der vorhergehenden Ansprüche 1 bis 13, **dadurch gekennzeichnet, daß** die Steuerung (10) den Motor (2) in einem Energieerzeugungsmodus zum Erzeugen von Elektroenergie durch Absorbieren von Energie des Verbrennungsmotors (1) befähigt, wenn die tatsächliche Motordrehzahl höher als die Ziehldrehzahl ist.

15. Fahrzeug nach zumindest einem der vorhergehenden Ansprüche 1 bis 14, **dadurch gekennzeichnet, daß** in dem automatischen Motomeustartbetrieb die Steuerung (10) zuerst den Verbrennungsmotor (1) mit dem Motor (2) ohne Kraftstoffeinspritzung für eine vorbestimmte Zeitdauer ankurbelt, um eine Verbrennungsmotorverstärkung auf ein vorbestimmtes Niveau zu erhöhen und die Kraftstoffzuführung zu dem Verbrennungsmotor (1) am Ende der vorbestimmten Zeitdauer startet.

16. Fahrzeug nach zumindest einem der vorhergehenden Ansprüche 1 bis 15, **dadurch gekennzeichnet, daß** das Fahrzeug außerdem eine ölpumpe (14) aufweist, um Öldruck zu dem automatischen Getriebe (3) zuzuführen, selbst wenn der Verbrennungsmotor (1) im Stillstand ist.

17. Automatische Stopp- und Neustart- Steuervorrichtung zum automatischen Anhalten eines Verbrennungsmotors (1) für ein Fahrzeug und zum automatischen Neustarten des Verbrennungsmotors (1) mit einem Startermotor (2), wobei die automatische Motorstopp- und Neustart- Steuervorrichtung aufweist:

eine Einrichtung zum automatischen Stoppen des Verbrennungsmotors (1) in einer vorbestimmten Fahrzeugsituation;
eine Einrichtung zum Überwachen eines Antriebszustandes eines automatischen Getriebes (3), verbunden mit dem Verbrennungsmotor (1), **gekennzeichnet durch** eine Einrichtung zum Erzeugen eines automatischen Neustartanforderungssignales in Übereinstimmung mit einem Fahrzeugbetriebszustand in einer vorbestimmten Fahrzeugsituation;
eine Einrichtung zum Bestimmen einer Ziehlmotordrehzahl für einen automatischen Motomeustartbetrieb in Übereinstimmung mit dem Antriebszustand des automatischen Getriebes (3); und
eine Einrichtung für das Neustarten des Verbrennungsmotors (1) in Abhängigkeit von einem automatischen Motomeustart- Anforderungssignales **durch** Steuem des Startermotors (2) in Übereinstimmung mit der Ziehlmotordrehzahl.

18. Automatisches Motorstopp- und Neustart- Steuerungsverfahren zum automatischen Stoppen eines Verbrennungsmotors (1) für ein Fahrzeug und automatisches Neustarten des Verbrennungsmotors (1) mit einem Startermotor (2), wobei das automatische Motorstopp- und Neustart- Steuerungsverfahren aufweist:

Versetzen des Verbrennungsmotors (1) in einen automatischen Stoppzustand in einer vorbestimmten Fahrzeugsituation;
Erfassen eines Antriebszustandes eines mit einem Verbrennungsmotor (1) verbundenen automatischen Getriebes (3), **gekennzeichnet durch**
Erzeugen eines automatischen Neustart- Anforderungssignales in Übereinstimmung mit einem Fahrzeugbetriebszustand in einer vorbestimmten Fahrzeugsituation; Bestimmen einer Ziehlmotordrehzahl für einen automatischen Motomeustartbetrieb in Übereinstimmung mit dem Antriebszustand des automatischen Getriebes (3); und
Initiieren des automatischen Motomeustartbetriebes zum Neustarten des Verbrennungsmotors (1) in Abhängigkeit von dem automatischen Motomeustart- Anforderungssignal **durch** Steuem des Startmotors (2) in Übereinstimmung mit der Ziehlmotordrehzahl.

Revendications

1. Véhicule comprenant :

un moteur (1) ;
un moteur (2) pour démarrer le moteur (1) ;
une transmission automatique (3) connectée au moteur (1) et au moteur (2) pour recevoir la rotation d'entrée du moteur (1) et du moteur (2) et pour réaliser une rotation de sortie afin d'entraîner le véhicule ;
un dispositif de détection (9, 11, 15, 18) pour détecter un état de fonctionnement du véhicule ; et
un dispositif de commande (10, 12) pour exé-

cuter une opération d'arrêt de moteur automatique pour arrêter automatiquement le moteur (1) et une opération de redémarrage automatique du moteur pour redémarrer automatiquement le moteur (1) en accord avec l'état de fonctionnement du véhicule, pour produire un signal de demande de redémarrage du moteur pour demander un redémarrage du moteur (1) pendant l'opération d'arrêt automatique du moteur, **caractérisé en ce que** ledit dispositif de commande (10) est apte à déterminer une vitesse cible du moteur pour l'opération de redémarrage automatique du moteur et pour exécuter l'opération de redémarrage automatique du moteur, en réponse au signal de demande de redémarrage du moteur, en entraînant le moteur en accord avec la vitesse cible tout en maintenant inchangé un état de transmission de la transmission automatique (3).

2. Véhicule selon la revendication 1, **caractérisé en ce que** le dispositif de commande (10) est configuré pour exécuter l'opération de redémarrage automatique du moteur en réponse au signal de demande de redémarrage du moteur et à maintenir la transmission automatique (3) dans une plage d'entraînement pendant l'opération de redémarrage automatique du moteur si la transmission automatique se trouve dans la plage d'entraînement au début de l'opération de redémarrage du moteur.

3. Véhicule selon la revendication 1 ou 2, **caractérisé en ce que** le dispositif de commande (10) produit un premier signal de condition lorsqu'une pédale d'accélération du véhicule est enfoncée, un deuxième signal de condition lorsqu'une pédale de frein du véhicule est relâchée, un troisième signal de condition lorsqu'une vitesse du véhicule est augmentée depuis zéro, et un quatrième signal de condition lorsqu'une durée de temps de l'opération d'arrêt de moteur automatique devient égale ou supérieure à une longueur de temps prédéterminée, et le dispositif de commande (10) produit le signal de demande de redémarrage lorsqu'au moins l'un des premier, deuxième, troisième et quatrième signaux d'état est produit.

4. Véhicule selon au moins l'une des revendications précédentes 1 à 3, **caractérisé en ce que** le dispositif de détection comprend un détecteur d'accélération (15) pour détecter un état de la pédale d'accélération du véhicule, un détecteur de frein (11) pour détecter un état de la pédale de frein du véhicule et un détecteur de vitesse de véhicule (18) pour détecter la vitesse du véhicule, et le dispositif de commande (10) produit des premier, deuxième et troisième signaux de condition, respectivement, en accord avec des signaux du détecteur d'accélération (15), du détecteur de frein (11) et du détecteur de vitesse de véhicule (18).

5. Véhicule selon au moins l'une des revendications précédentes 1 à 4, **caractérisé en ce que** le dispositif de commande (10) détermine la vitesse cible du moteur pour l'opération de redémarrage automatique du moteur en accord avec un degré d'ouverture de l'accélérateur.

6. Véhicule selon la revendication 5, **caractérisé en ce que** le dispositif de commande (10) établit la vitesse cible du moteur pour qu'elle soit égale à une vitesse de ralenti lorsque le degré d'ouverture de l'accélérateur est égal à un réglage minimum.

7. Véhicule selon la revendication 5 ou 6, **caractérisé en ce que** le dispositif de commande (10) fait augmenter la vitesse cible du moteur pour l'opération de redémarrage automatique du moteur en accord avec le degré d'ouverture de l'accélérateur.

8. Véhicule selon au moins l'une des revendications précédentes 1 à 4, **caractérisé en ce que** le dispositif de commande (10) fait augmenter la vitesse cible du moteur pour l'opération de redémarrage automatique du moteur en accord avec un paramètre de fonctionnement qui est un parmi un temps qui s'est écoulé depuis le début de l'opération de redémarrage automatique du moteur et une vitesse du véhicule.

9. Véhicule selon la revendication 8, **caractérisé en ce que** le dispositif de commande (10) augmente une vitesse d'augmentation de la vitesse cible du moteur par rapport au paramètre au fur et à mesure que le degré d'ouverture de l'accélérateur augmente.

10. Véhicule selon la revendication 1, **caractérisé en ce que** le dispositif de commande (10) établit la vitesse cible du moteur pour l'opération de redémarrage automatique du moteur pour qu'elle soit égale à une vitesse de ralenti lorsque la transmission automatique (3) se trouve dans un état de non-entraînement dans lequel un couple d'entraînement n'est pas transmis par la transmission automatique (3).

11. Véhicule selon au moins l'une des revendications précédentes 1 à 10, **caractérisé en ce que** le dispositif de détection comprend en outre un détecteur d'état de transmission pour détecter un état de la transmission automatique (3) et, le dispositif de commande (10) vérifie l'état de la transmission automatique (3) en réponse au signal de demande de redémarrage et détermine la vitesse cible du moteur pour l'opération de redémarrage automatique

du moteur en accord avec l'état de la transmission automatique (3).

12. Véhicule selon au moins l'une des revendications précédentes 1 à 11, **caractérisé en ce que** le dispositif de commande (10) commande un couple du moteur (1) et un couple du moteur (2) lors de l'opération de redémarrage automatique du moteur de façon à amener une vitesse actuelle du moteur à être égale à la vitesse cible.

13. Véhicule selon la revendication 12, **caractérisé en ce que** le dispositif de détection comprend un détecteur de vitesse de moteur (9) pour détecter une vitesse actuelle du moteur (1), et le dispositif de commande (10) commande le moteur (2) lors de l'opération de redémarrage automatique du moteur de manière à réduire un écart de la vitesse actuelle du moteur de la vitesse cible du moteur.

14. Véhicule selon au moins l'une des revendications précédentes 1 à 13, **caractérisé en ce que** le dispositif de commande (10) actionne le moteur (2) en mode générateur de puissance pour générer de la puissance électrique en absorbant l'énergie du moteur (1) lorsque la vitesse actuelle du moteur est plus élevée que la vitesse cible.

15. Véhicule selon au moins l'une des revendications précédentes 1 à 14, **caractérisé en ce que** lors de l'opération de redémarrage automatique du moteur, le dispositif de commande (10) lance d'abord le moteur (1) avec le moteur (2) sans injection de carburant pendant une durée de temps prédéterminée afin d'augmenter une suralimentation du moteur à un niveau prédéterminé et commence l'amenée du carburant au moteur (1) à la fin de la durée de temps prédéterminée.

16. Véhicule selon au moins l'une des revendications précédentes 1 à 15, **caractérisé en ce que** le véhicule comprend en outre une pompe à huile (14) pour fournir une pression d'huile à la transmission automatique (3) même lorsque le moteur (1) est au repos.

17. Appareil de commande automatique d'arrêt et de redémarrage du moteur pour arrêter automatiquement un moteur (1) pour un véhicule et pour redémarrer automatiquement le moteur (1) avec un moteur de démarrage (2), l'appareil de commande d'arrêt et de redémarrage automatique du moteur comprenant :

un moyen pour arrêter automatiquement le moteur (1) dans une situation prédéterminée du véhicule ; un moyen pour surveiller un état d'entraînement d'une transmission automatique (3) reliée au moteur (1),

caractérisé par
un moyen pour produire un signal de demande de redémarrage automatique en accord avec un état de fonctionnement du véhicule dans la situation prédéterminée du véhicule ;
un moyen pour déterminer une vitesse cible du moteur pour une opération de redémarrage automatique du moteur en accord avec l'état d'entraînement de la transmission automatique (3) ; et
un moyen pour redémarrer le moteur (1) en réponse au signal de demande de redémarrage automatique du moteur, en commandant le moteur de démarrage (2) en accord avec la vitesse cible du moteur.

18. Procédé de commande d'arrêt et de redémarrage automatique du moteur pour arrêter automatiquement un moteur (1) d'un véhicule et pour redémarrer automatiquement le moteur (1) avec un moteur de démarrage (2), le procédé de commande d'arrêt et de redémarrage automatique du moteur comprenant les étapes consistant à :

mettre le moteur (1) dans un état d'arrêt automatique dans une situation prédéterminée du véhicule ;
détecter un état d'entraînement d'une transmission automatique (3) reliée au moteur (1), **caractérisé par** les étapes consistant à
produire un signal de demande de redémarrage automatique en accord avec un état de fonctionnement du véhicule dans la situation prédéterminée du véhicule ;
déterminer une vitesse cible du moteur pour une opération de redémarrage automatique du moteur en accord avec l'état d'entraînement de la transmission automatique (3) ; et
initier l'opération de redémarrage automatique du moteur pour redémarrer le moteur (1) en réponse au signal de demande de redémarrage automatique du moteur, en commandant le moteur de démarrage (2) en accord avec la vitesse cible du moteur.

FIG.1

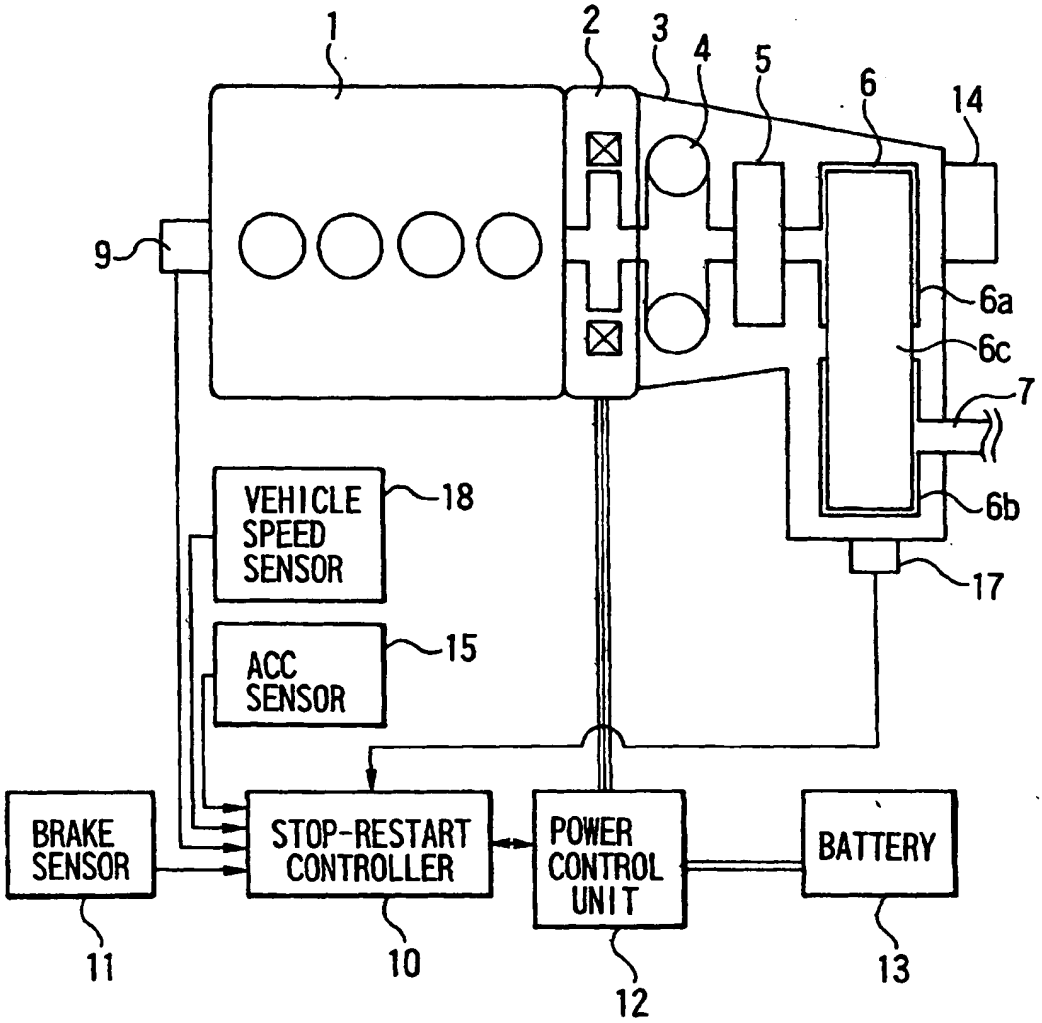

1
2
3
4
5
6
14
9
6a
6c
7
6b
17
VEHICLE SPEED SENSOR
18
ACC SENSOR
15
BRAKE SENSOR
STOP-RESTART CONTROLLER
POWER CONTROL UNIT
BATTERY
11
10
12
13

FIG.2

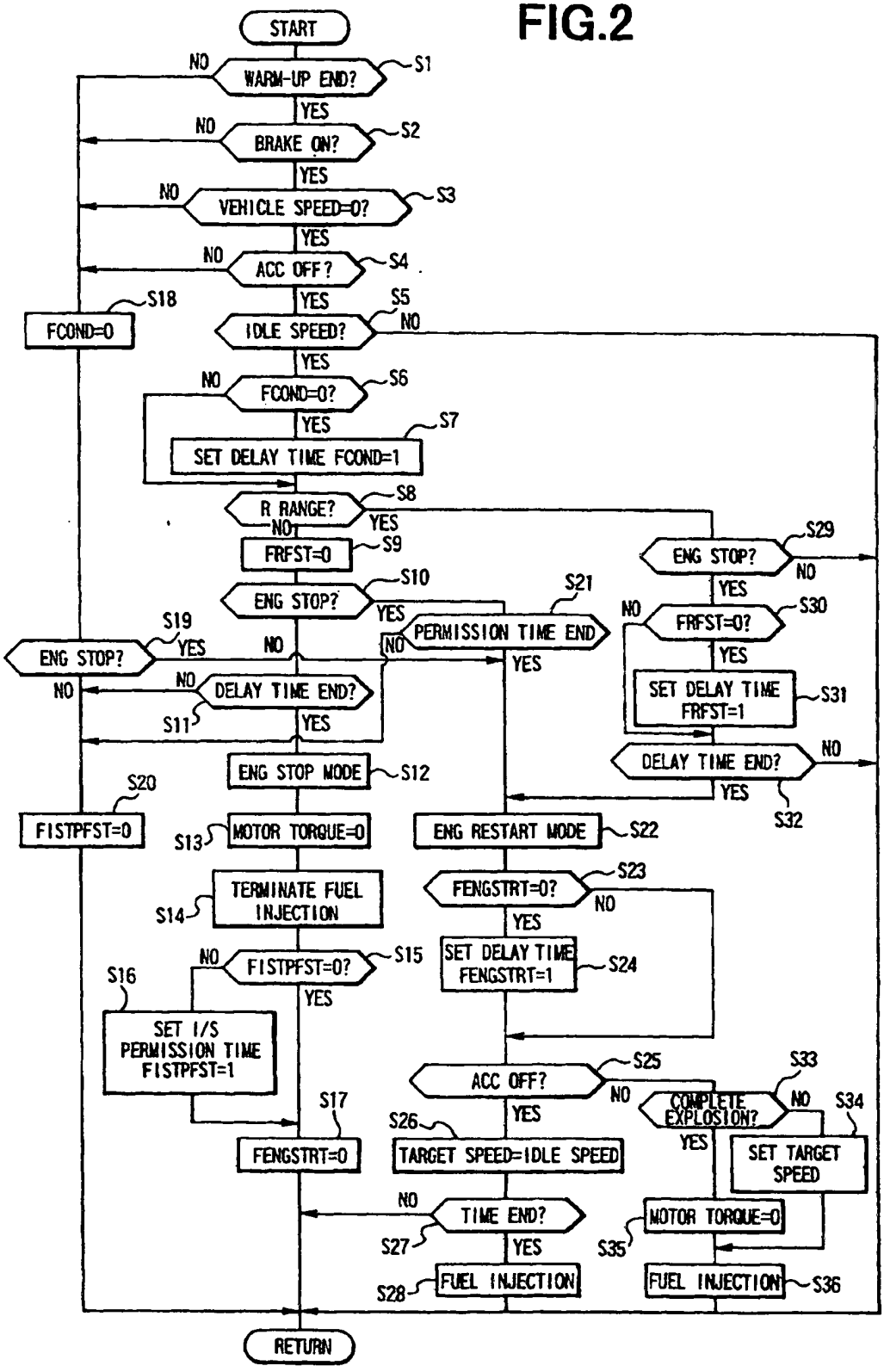

START
WARM-UP END?
S1
NO
YES
BRAKE ON?
S2
VEHICLE SPEED=0?
S3
ACC OFF?
S4
IDLE SPEED?
S5
FCOND=0
S18
FCOND=0?
S6
SET DELAY TIME FCOND=1
S7
R RANGE?
S8
FRFST=0
S9
ENG STOP?
S10
PERMISSION TIME END
S21
ENG STOP?
S19
DELAY TIME END?
S11
ENG STOP MODE
S12
FISTPFST=0
S20
MOTOR TORQUE=0
S13
TERMINATE FUEL INJECTION
S14
FISTPFST=0?
S15
SET I/S PERMISSION TIME FISTPFST=1
S16
FENGSTRT=0
S17
ENG STOP?
S29
FRFST=0?
S30
SET DELAY TIME FRFST=1
S31
DELAY TIME END?
S32
ENG RESTART MODE
S22
FENGSTRT=0?
S23
SET DELAY TIME FENGSTRT=1
S24
ACC OFF?
S25
TARGET SPEED=IDLE SPEED
S26
TIME END?
S27
FUEL INJECTION
S28
COMPLETE EXPLOSION?
S33
SET TARGET SPEED
S34
MOTOR TORQUE=0
S35
FUEL INJECTION
S36
RETURN

FIG.3

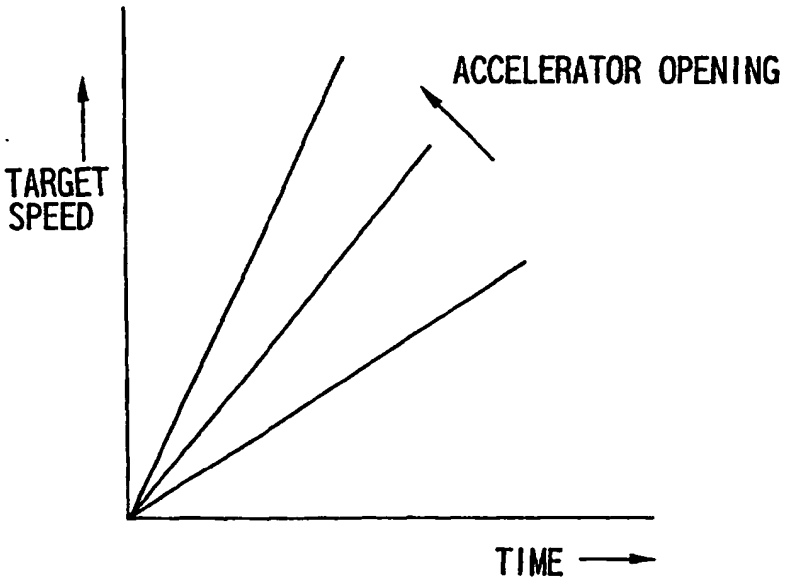


FIG.4

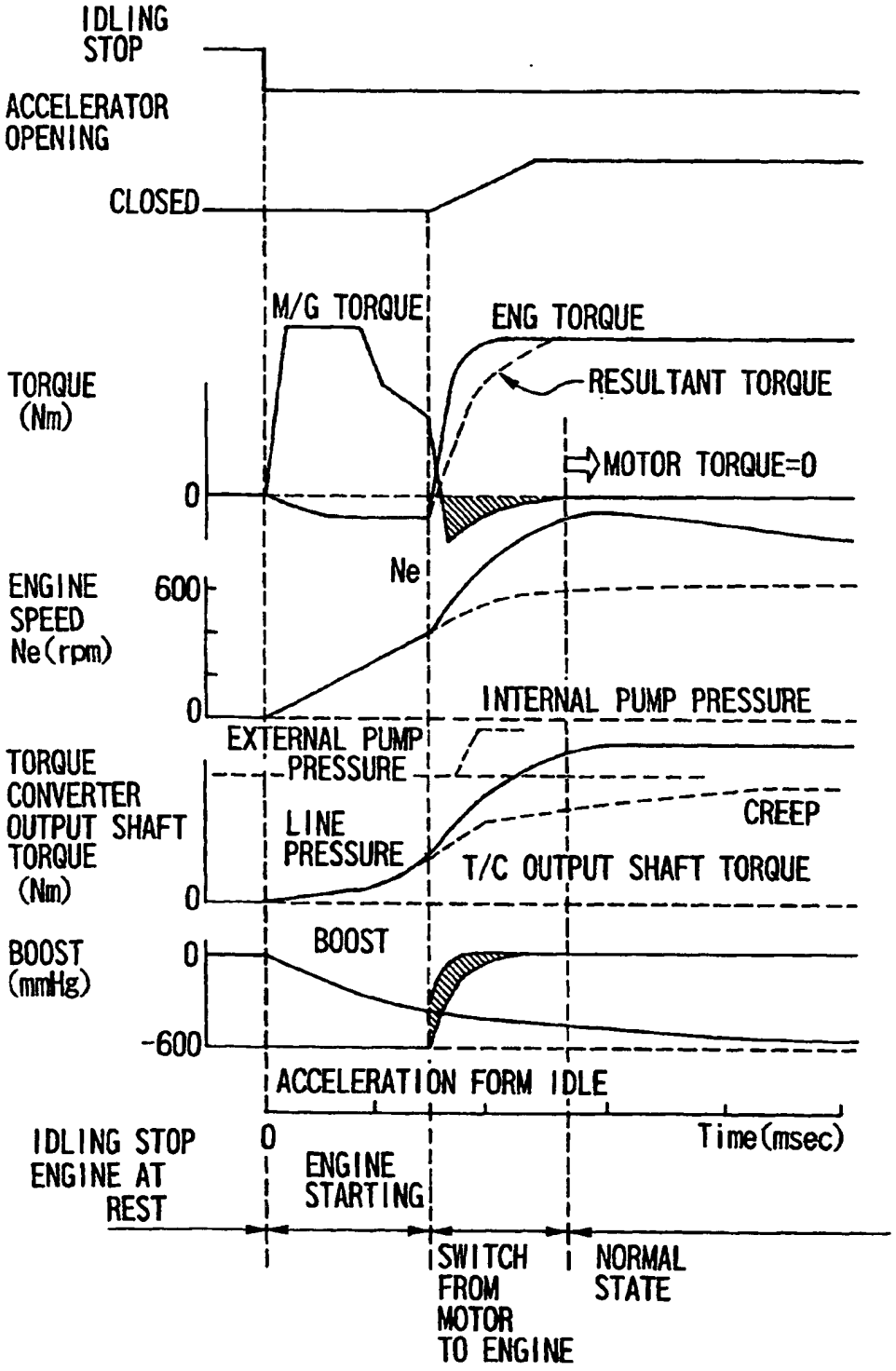
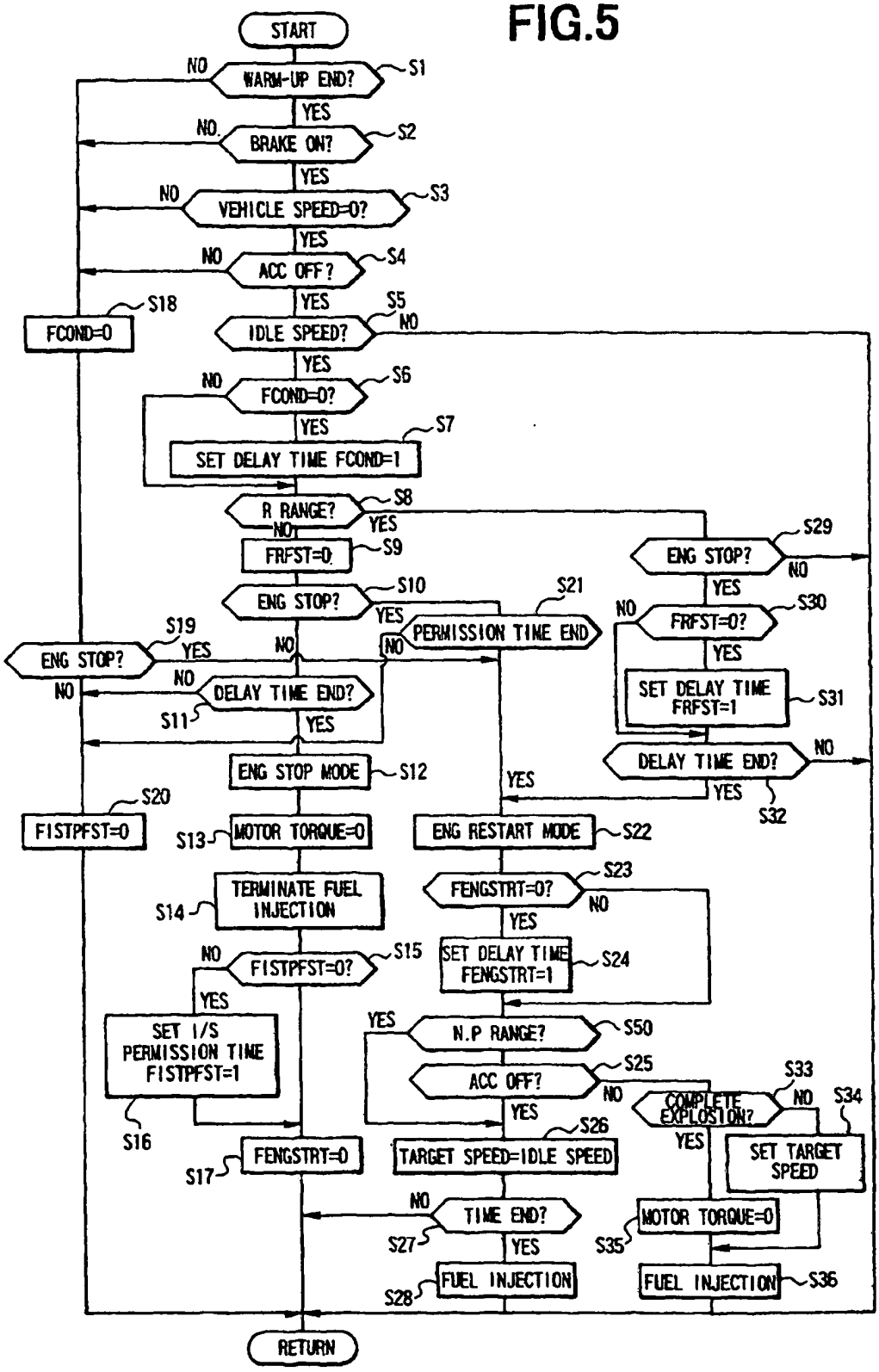

IDLING STOP
ACCELERATOR OPENING
CLOSED
M/G TORQUE
ENG TORQUE
RESULTANT TORQUE
TORQUE (Nm)
0
MOTOR TORQUE=0
ENGINE SPEED Ne(rpm)
600
Ne
0
INTERNAL PUMP PRESSURE
EXTERNAL PUMP PRESSURE
TORQUE CONVERTER OUTPUT SHAFT TORQUE (Nm)
LINE PRESSURE
CREEP
T/C OUTPUT SHAFT TORQUE
0
BOOST (mmHg)
BOOST
0
-600
ACCELERATION FORM IDLE
IDLING STOP ENGINE AT REST
0
Time(msec)
ENGINE STARTING
SWITCH FROM MOTOR TO ENGINE
NORMAL STATE

FIG.5


START
WARM-UP END?
S1
NO
YES
BRAKE ON?
S2
VEHICLE SPEED=0?
S3
ACC OFF?
S4
IDLE SPEED?
S5
FCOND=0
S18
FCOND=0?
S6
SET DELAY TIME FCOND=1
S7
R RANGE?
S8
FRFST=0
S9
ENG STOP?
S10
PERMISSION TIME END
S21
ENG STOP?
S19
DELAY TIME END?
S11
ENG STOP MODE
S12
FISTPFST=0
S20
MOTOR TORQUE=0
S13
TERMINATE FUEL INJECTION
S14
FISTPFST=0?
S15
SET I/S PERMISSION TIME FISTPFST=1
S16
FENGSTRT=0
S17
ENG RESTART MODE
S22
FENGSTRT=0?
S23
SET DELAY TIME FENGSTRT=1
S24
N.P RANGE?
S50
ACC OFF?
S25
TARGET SPEED=IDLE SPEED
S26
TIME END?
S27
FUEL INJECTION
S28
ENG STOP?
S29
FRFST=0?
S30
SET DELAY TIME FRFST=1
S31
DELAY TIME END?
S32
COMPLETE EXPLOSION?
S33
SET TARGET SPEED
S34
MOTOR TORQUE=0
S35
FUEL INJECTION
S36
RETURN